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Planning human resources and facilities to achieve Sustainable Development Goals: a decision-analytical modelling approach to predict cancer control requirements in Indonesia

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ABSTRACT

Objectives Indonesia aims to achieve universal health coverage (UHC) and Sustainable Development Goals (SDGs), including SDG 3 target 4, which focuses on cancer control, by 2030. This study aimed to forecast the human resources for health (HRH) and facilities required for cancer control in Indonesia over an 11-year period to support these goals.

Design A two-stage Markov model was developed to forecast the demand side of facilities and HRH requirements for cancer control in Indonesia over an 11-year period.

Setting Data sources used include the Indonesia Health Profile Report (2019), the Indonesian Radiation Oncology Society Database and National Cancer Control Committee documents (2019).

Methods The study involved modelling the current availability of HRH and healthcare facilities in Indonesia and predicting future requirements. The gap between the current and the required HRH and facilities related to oncology, and the costs associated with meeting these requirements, were analysed.

Results Results indicate the need to increase the number of healthcare facilities and HRH to achieve SDG targets. However, UHC for cancer care still may not be achieved, as eastern Indonesia is predicted to have no tertiary hospital until 2030. The forecast shows that Indonesia had a median of only 39% of the HRH requirements in 2019. Closing the HRH gap requires around a 47.6% increase in salary expenditure.

Conclusion This study demonstrates the application of decision-analytical modelling approach to planning HRH and facilities in the context of a low-to-middle-income country. Scaling up oncology services in Indonesia to attain the SDG targets will require expansion of the number and capability of healthcare facilities and HRH. This work allows an in-depth understanding of the resources needed to achieve UHC and SDGs and could be utilised in other disease areas and contexts.

Strengths and limitations of this study

- ⇒ The study employed decision-analytical modelling (using a Markov model as part of a health service development approach) to empirically forecast oncology workforce requirements on annual basis to provide evidence-based information to support human resources for health (HRH) and facilities planning and policy development in a low-and-middle-income country (LMIC) context.
- ⇒ The study used the case study of Indonesia to highlight some of the challenges experienced by LMICs in relation to HRH planning.
- ⇒ The study focused only on oncology services in the public sector for HRH of the ten most common cancers in Indonesia and forecasted the demand-side of the required HRH.
- ⇒ As the model was based on an annual planning cycle, which is a discrete-time process, the typical Markov model features such as discounting and half-cycles correction were not applied in this model.

INTRODUCTION

Health workforce provision and planning play a fundamental role in achieving universal health coverage (UHC) and the UN's health-related Sustainable Development Goals (SDGs).[1] Achieving these targets requires a robust healthcare delivery system with the health workforce as the core of the system.[2] The healthcare system relies heavily on its workforce, more than any other type of organisation.[3] Reducing premature mortality from non-communicable diseases, including cancer, by one-third by 2030 is one of the key areas of attention for the SDGs, with one of the SDGs (SDG 3 target 4) particularly focussing on cancer control. With cancer now being the second leading cause of death worldwide, the World Health Organisation (WHO) has highlighted the importance of effective human resources for health (HRH) planning as one of the essential interventions in addressing cancer.[4] HRH planning is particularly important in low-and-middle-income countries (LMICs), where 70% of global cancer deaths are estimated to occur and healthcare systems are still in transition to achieve UHC.[4] In this context, population growth and cancer incidence often outpace the development of cancer services.

Indonesia provides a useful example of some of the challenges experienced by LMICs in relation to HRH planning. The exponential growth of the population has also put a strain on the national health insurance system to provide UHC for all the residents. Concurrently, the burden of cancer is growing in this country, with cases rising from 726555 in 2014 to just under 1.8 million cases in 2018, representing a 97.5% increase over a 4-year period.[5] Although this increase is not only due to an increase in population growth and trends, but also due to improvements in awareness, data capture and reporting[6 7]; unfortunately, more than 70% of these patients with cancer are still diagnosed at a late stage,[8] resulting in a higher financial burden and lower survival rates. The limited access to oncology services is known to be a contributing factor, as the oncology workforce and healthcare facilities are inadequate in their volume and they are unequally distributed geographically.[9 10]

Despite these challenges, Indonesia has been making large strides towards controlling cancer through investments in healthcare facilities to improve access to oncology services. The National Cancer Control Plan and the Strategic National Cancer Plan of Action have also been developed in order to strengthen cancer control in Indonesia, with HRH planning as one of its core priorities.[11 12] As cancer care has one of the most complex HRH patterns, national level analyses to determine HRH-related oncology requirements on a year-by-year basis are crucial to ensure adequate planning and to enhance effective annual budgeting. However, many LMICs, including Indonesia, offer no official guidelines for calculating the number of oncologists needed.

In LMICs, where data and evidence availability are one of the major constraints, decision-analytical models can be extremely useful for HRH planning. Such models use mathematical relationships to synthesise evidence from various sources and can be used to extrapolate information over defined time periods.[13 14] A Markov model is one kind of modelling framework that is often used to model disease evolution and treatment. However, the application of this model for HRH planning has only been explored recently. This type of model is able to describe the behaviour of a system in dynamic situations over time and can be adapted to incorporate the key components of HRH planning.[15] Therefore, this type of model can provide a flexible tool for planners to analyse the changing number and distribution of facilities and workers required in different situations.[16]

Using a Markov model, this paper aims to forecast the HRH and facilities required for cancer control in Indonesia over the next 11 years, in order to support the goal of achieving UHC and SDG targets by 2030. The results will provide evidence-based information to support HRH planning and policy development to support cancer control in the country. This study will also examine the strengths and limitations of such modelling methods in this context.

METHODS

Indonesian context

Indonesia is the world's largest archipelago country, comprising more than 16000 islands. Administratively, it is divided into 34 provinces and can be further grouped into seven regions based on geographical location. With an annual population growth rate of 1.43%, the population was estimated to reach over 260 million people by 2019.[17] However, there is uneven population growth and distribution among provinces, with the Java region being the most densely populated area. Most of the healthcare facilities and the oncology workforces are also concentrated in this area.

In Indonesia, cancer services operate as a multilevel system, starting from the outpatient and inpatient *Puskesmas* at the primary level, followed by type D, C and B hospitals at the secondary level, and capped by type A hospitals as the highest tertiary level provision. Healthcare facilities are categorised according to their scope and capacity per head of population (online supplemental appendix 1). The status of services can change annually based on the assessment of their resources, plans and scope by the Ministry of Health (MoH). Lower-level healthcare facilities can be upgraded to higher level facilities to improve access, quality, capacity and the number of HRH.[18] However, hospitals can also be downgraded if they do not meet the standard criteria due to their inability to maintain their facilities or HRH on annual inspection.[19]

Modelling approach

There is no universally accepted conceptual approach to forecasting HRH requirements. Each approach relies on assumptions and the approach adopted usually depends on data availability, the planner's capacity and the nature of the healthcare system.[20 21] For this study, the health service development analysis approach was selected and applied for demand-side forecasting of HRH and facilities for Indonesia's context, given the relatively simple data requirements.[21] It also allows a realistic consideration of the infrastructural expansion plan. Moreover, Indonesia-specific staffing standards could be used to generate aggregate oncology workforce requirements.

A two-stage model was conducted. First, a Markov model was analytically used to estimate the future number of healthcare facilities. Staffing standards were subsequently used to translate the number of healthcare facilities in each level into HRH requirements. The forecasting analysis was conducted using Microsoft Excel V.16.33. Patients or the public were not involved in the design, conduct, or reporting of this study, as the focus was on applying the analytical techniques to a particular case study.

Model structure and assumptions

The model structure reflects the system of facilities and is illustrated in figure 1. The patient movement from one

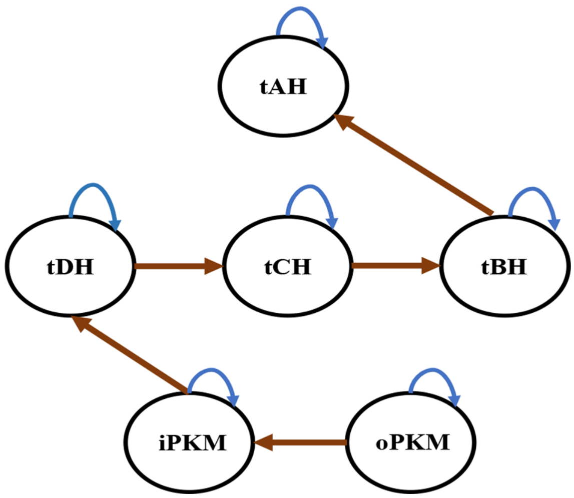


Figure 1 Model structure of healthcare facilities for cancer service in Indonesia. iPKM, inpatient *Puskesmas*; oPKM, outpatient *Puskesmas*; tAH, type A Hospital; tBH, type B Hospital; tCH, type C Hospital; tDH, type D Hospital.

health state to another in the typical Markov model is analogous to the transition from one type of facility to another in this model. Each type of health facility is deemed as a 'state', resulting in six possible states including outpatient Puskesmas, inpatient Puskesmas, type D hospital, type C hospital, type B hospital and type A hospital. The healthcare facilities were modelled in one state during one cycle and could switch to another category or 'state' (according to transition probabilities) in the following cycle.

Although the downgrading of facilities is theoretically possible, this model assumed that healthcare facilities could only transition to the next higher level or remain in the same category. This assumption was based on the fact that cases of downgrading are rare, and staff are not usually expelled from one facility due to a downgrading in a given year. It was further assumed that healthcare facilities would not be closed down because the unmet oncology service needs are still high in Indonesia.[9 22] Based on these assumptions, the average number of new facilities at each level each year was derived and taken into account in the model structure. In figure 1, straight arrows show the transition pathways over successive cycles. Circular arrows indicate that the healthcare facilities can remain in the same category for more than one cycle.

Cycle length, time horizon and transition probabilities

As the healthcare facilities and HRH data are usually analysed annually, a 1-year cycle length was used in the model. The time horizon was 11 years to ensure the achievement of SDGs by 2030. The literature also suggests that HRH forecasting tends to lose value if the time horizon is much longer than 10 years because of the dynamics of the rapidly changing health industry.[20] As the model was based on an annual planning cycle, which is a discrete-time process, the typical Markov model features such as discounting and half-cycle correction were not applied in this model.

Table 1 Model input parameters

Parameters for transition probability	Base value	SE	95% CI
Region 1 (Sumatera)		0.002	
▶ oPKM to iPKM	0.121	0.004	0.113 to 0.129
▶ iPKM to tDH	0.031	0.002	0.027 to 0.035
▶ tDH to tCH	0.296	0.006	0.285 to 0.307
▶ tCH to tBH	0.008	0.001	0.006 to 0.010
▶ tBH to tAH	0.013	0.001	0.011 to 0.016
Region 2 (Java)			
▶ oPKM to iPKM	0.112	0.003	0.105 to 0.118
▶ iPKM to tDH	0.043	0.002	0.039 to 0.047
▶ tDH to tCH	0.247	0.004	0.238 to 0.255
▶ tCH to tBH	0.032	0.002	0.029 to 0.036
▶ tBH to tAH	0.010	0.001	0.008 to 0.012
Region 3 (Bali and the Nusa Tenggara)			
▶ oPKM to iPKM	0.056	0.006	0.045 to 0.068
▶ iPKM to tDH	0.014	0.003	0.008 to 0.020
▶ tDH to tCH	0.241	0.011	0.219 to 0.263
▶ tCH to tBH	0.023	0.004	0.015 to 0.031
▶ tBH to tAH	0.000	0.000	0.000 to 0.000
Region 4 (Kalimantan)			
▶ oPKM to iPKM	0.088	0.006	0.076 to 0.100
▶ iPKM to tDH	0.018	0.003	0.012 to 0.023
▶ tDH to tCH	0.315	0.010	0.296 to 0.335
▶ tCH to tBH	0.012	0.002	0.007 to 0.017
▶ tBH to tAH	0.012	0.002	0.007 to 0.016
Region 5 (Sulawesi)			
▶ oPKM to iPKM	0.039	0.004	0.032 to 0.046
▶ iPKM to tDH	0.019	0.002	0.014 to 0.023
▶ tDH to tCH	0.364	0.009	0.347 to 0.382
▶ tCH to tBH	0.012	0.002	0.008 to 0.016
▶ tBH to tAH	0.008	0.002	0.005 to 0.011
Region 6 (Maluku)			
▶ oPKM to iPKM	0.151	0.012	0.128 to 0.173
▶ iPKM to tDH	0.032	0.006	0.021 to 0.043
▶ tDH to tCH	0.041	0.006	0.029 to 0.054
▶ tCH to tBH	0.027	0.005	0.017 0.037
▶ tBH to tAH	0.000	0.000	0.000 to 0.000
Region 7 (Papua)			
▶ oPKM to iPKM	0.170	0.009	0.152 to 0.188
▶ iPKM to tDH	0.040	0.005	0.030 to 0.050
▶ tDH to tCH	0.087	0.007	0.073 to 0.101
▶ tCH to tBH	0.000	0.000	0.000 to 0.000
▶ tBH to tAH	0.000	0.000	0.000 to 0.000

Source: Indonesia Health Report 2019 (MoH, 2019b).
iPKM, inpatient *Puskesmas*; MoH, Ministry of Health; oPKM, outpatient *Puskesmas*; tAH, type A Hospital; tBH, type B Hospital; tCH, type C Hospital; tDH, type D Hospital.

Movements between states are defined by transition probabilities, which indicate the chance of a healthcare facility status changing within a 1-year time cycle. Transitions from one category of healthcare facility to another were analysed to derive transition probabilities which are presented in table 1. The transition probabilities were derived from routine data on healthcare facilities from 2015 to 2019,[23] which were then converted into the annual probabilities used in the model. As the development of each region varies, different transition probabilities were used for each region.

Existing number of healthcare facilities and projections for future years

The number of existing healthcare facilities in Indonesia from 2015 to 2019 was taken from the Indonesia Health Profile Report 2019. However, there were several hospitals that had not been classified each year from 2015 to 2019. Therefore, those hospitals were assumed to be classified as a particular type based on the proportion of each hospital within each category within each year to obtain the baseline number of healthcare facilities. The number of healthcare facilities was calculated based on the possible movements of health facilities in the model structure and the associated transition probabilities.

HRH requirements computation

The HRH requirements were estimated reflecting national staffing norms. The staffing norm defines the minimum number and type of HRH required in each type of facilities to deliver healthcare. The staffing norms used in this model were taken from MoH staffing standard and from the guidelines developed by the National Cancer Control Committee (NCCC) (online supplemental appendix 2). Estimates of the required HRH were then the results of the calculated staffing levels and the total number of each type of healthcare facilities in a certain year as projected using the predictive model (online supplemental appendix 3). Furthermore, the national HRH requirement was calculated as a summation of HRH requirements in the seven regions in Indonesia.

HRH gaps and aggregate salaries cost

The HRH gap was analysed by comparing the current HRH availability with the projected HRH requirements. This analysis is useful especially for the recruitment and deployment of HRH planning and the management of wage bills.[24] A ratio of the current HRH availability to projected requirements, which is also called the Staff-Availability-Ratio (SAR), was also presented. The annual gross salaries were taken from the January 2020 payroll in one national public referral hospital in Indonesia (Indonesian Radiation Oncology Society, Staff Salary Survey 2019, Unpublished). A 10% annual increase in salary level was assumed based on the increasing salary in previous years. All costs were converted from Indonesian Rupiah (IDR) to British Pounds Sterling (£) based on 20 July 2020 exchange rate of £1 to IDR18 478.29.[25]

Sensitivity analysis

A series of deterministic sensitivity analysis (SA) were conducted to explore the uncertainty around the point estimates of HRH requirements and costs. A series of one-way SA were undertaken. This involved varying the transition probabilities in the predictive health facilities model according to their 95% confidence intervals (CIs) while the remaining values were held at their baseline values. Only one input was varied at a time. The model output produced, including the number of healthcare facilities, HRH requirements and salary costs, represented the lower and upper limits of the predictive interval which depict a range within the observed value is expected.[26] Probabilistic SA was not carried out in this model as it would produce various results that would not be meaningful in this context to guide a decision. An extension of one-way SA in the form of best-case and worst-case scenarios was also conducted, and these were defined as the lowest and highest cost estimates that the government would need to provide in order to meet the future required HRH, respectively. The combination of the lower estimates of healthcare facilities and estimated HRH requirements as well as the minimal standard staffing salaries were used to calculate the 'best-case' scenario, while the combination of the upper estimates and maximal staffing salaries were assumed to represent the 'worst-case' scenario.

Patient and public involvement

Study participants or the public were not involved in the design, conduct, reporting or development of the dissemination plans of our research. The study was unfunded and involved the modelling of the HRH and facilities required for cancer control using published data.

RESULTS

Healthcare facilities forecasting

The forecast (table 2) shows a significant increase in the total number of healthcare facilities, from 13 011 in 2019 to 27 935 facilities in 2030 (a 114.7% increase over the 11-year period). A steady increase is estimated across all healthcare facilities, excluding the outpatient Puskesmas. The number of outpatient Puskesmas is predicted to decrease by almost half compared with the baseline level, from 4048 in 2019 to 2064 in 2030, as they expand and move into inpatient Puskesmas. This reflects the fact that at the primary care level, the number of outpatient Puskesmas has decreased over the last 5-year period from 6358 in 2015 to 4048 in 2019 and the number of inpatient Puskesmas has increased almost twofold at the same time from 3396 in 2015 to 6086 in 2019. Consequently, the number of inpatient Puskesmas is predicted to increase from 6086 in 2019 to 14 015 in 2030.

The continued growth of healthcare facilities is also predicted at the secondary level, where the requirement for type C hospitals will rise by almost 400% from the baseline in 2019, followed by type B and type D hospitals. At the tertiary level, the number of type A hospitals is also estimated to increase steadily from 61 in 2019 to 87 in 2030, representing an increase of 42.6%. However, significant differences exist at the regional level (online supplemental appendix 4–10), particularly for the development

Table 2 Projected healthcare facilities and the aggregate HRH-related oncology requirements in Indonesia 2019–2030

Health facility/year	Baseline 2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Outpatient Puskesmas	4048	3745	3475	3236	3024	2835	2667	2517	2384	2265	2159	2064
Inpatient Puskesmas	6086	7066	7978	8829	9625	10 370	11 070	11 729	12 350	12 936	13 490	14 015
Type D hospital	867	1108	1324	1519	1697	1862	2015	2158	2293	2420	2540	2655
Type C hospital	1514	1892	2322	2794	3302	3840	4402	4987	5590	6208	6840	7483
Type B hospital	435	492	559	634	720	815	922	1040	1170	1311	1466	1632
Type A hospital	61	65	67	69	70	72	75	77	79	82	85	87
Total health facilities	13 011	14 368	15 725	17 081	18 438	19 795	21 152	22 508	23 865	25 222	26 579	27 935
Staff type												
General practitioner	33 855	39 362	45 047	50 901	56 916	63 083	69 396	75 850	82 439	89 160	96 007	102 978
Nurse	301 257	353 246	408 891	468 153	530 893	596 998	666 372	738 934	814 609	893 329	975 033	1 059 660
Paediatrician	5880	7121	8470	9919	11 462	13 092	14 806	16 599	18 467	20 409	22 420	24 498
Obstetrician and gynaecologist	5880	7121	8470	9919	11 462	13 092	14 806	16 599	18 467	20 409	22 420	24 498
Internist	5880	7121	8470	9919	11 462	13 092	14 806	16 599	18 467	20 409	22 420	24 498
General surgeon	5880	7121	8470	9919	11 462	13 092	14 806	16 599	18 467	20 409	22 420	24 498
Anesthesiologist	3991	4802	5656	6559	7510	8510	9556	10 649	11 787	12 971	14 199	15 471
Radiologist	3434	4180	4964	5787	6650	7549	8485	9455	10 459	11 496	12 565	13 664
Clinical pathologist	3434	4180	4964	5787	6650	7549	8485	9455	10 459	11 496	12 565	13 664
Anatomical pathologist	2938	3623	4338	5085	5860	6662	7489	8339	9211	10 103	11 015	11 944
Surgical oncologist	557	622	692	771	860	960	1071	1193	1328	1475	1635	1807
Medical oncologist	496	557	625	703	790	888	996	1117	1249	1393	1550	1719
Paediatric medical oncologist	496	557	625	703	790	888	996	1117	1249	1393	1550	1719
Gynaecological oncologist	557	622	692	771	860	960	1071	1193	1328	1475	1635	1807
ENT oncologist	496	557	625	703	790	888	996	1117	1249	1393	1550	1719
Urological oncologist	496	557	625	703	790	888	996	1117	1249	1393	1550	1719
Pulmonological oncologist	496	557	625	703	790	888	996	1117	1249	1393	1550	1719
Radiation oncologist	496	557	625	703	790	888	996	1117	1249	1393	1550	1719
Medical physicist	496	557	625	703	790	888	996	1117	1249	1393	1550	1719
Radiation therapy technologist	496	557	625	703	790	888	996	1117	1249	1393	1550	1719
Total workforce	377 512	443 574	514 126	589 114	668 366	751 741	839 119	930 397	1 025 481	1 124 286	1 226 732	1 332 745

ENT, ears, nose and throat; HRH, human resources for health.

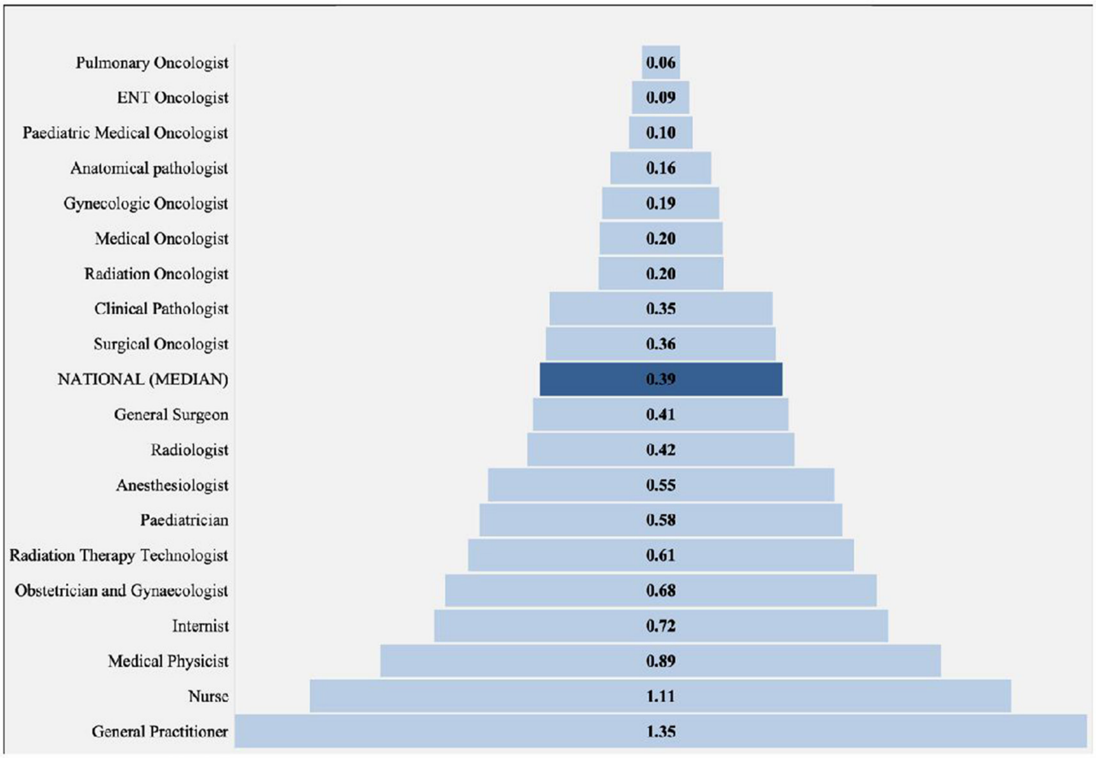


Figure 2 Staff-availability ratio. ENT, ears, nose and throat.

of secondary and tertiary healthcare facilities. Disparities are even greater in eastern Indonesia, such as the Maluku and Papua regions. Both regions are predicted to have no type A hospital and Papua region is expected to remain with the same number of type B hospitals (only two) until 2030.

HRH requirements forecasting, gaps and cost implications

The projected HRH requirements over the 11-year period can be seen in table 2. This model predicts a steady increase in HRH requirements across all staff categories from 2019 to 2030, except for the oncologist group in the Papua region (online supplemental appendix 4–10). The number of oncologists required in this region is estimated to be only two until 2030. Due to the regional disparities in the development of healthcare facilities as explained above, distributional imbalances in the health workforce are also expected. Health workers are concentrated in the Java region compared with other regions, and this trend is observed until 2030.

The SAR in figure 2 indicates the proportion of staff requirements that are met given these projections. Generally, the median national SAR (as of December 2019) was 39%. However, it varied widely from 3% to more than 100%. General practitioner (GP), nurse, internist and medical physicist were found to have an SAR of more than 70%. While radiation therapy technologists (RTTs) and other specialists, excluding general surgeon, were shown to have an SAR between 50% and 70%. The largest gap existed between the availability and requirements of oncologists. All the oncologists and general surgeons considered in this forecast were found to have an SAR below 50%, which is considered a severe shortage.

Salary costs

As the required staff volume is projected to increase each year, the rise in salary costs along the forecast period is also expected. In 2020, the annual salary cost for HRH of the ten most common cancers in Indonesia is estimated to reach about £3.9 billion. The cost for the predicted staffing requirement is found to steadily increase each year, to reach about £31.5 billion by 2030.

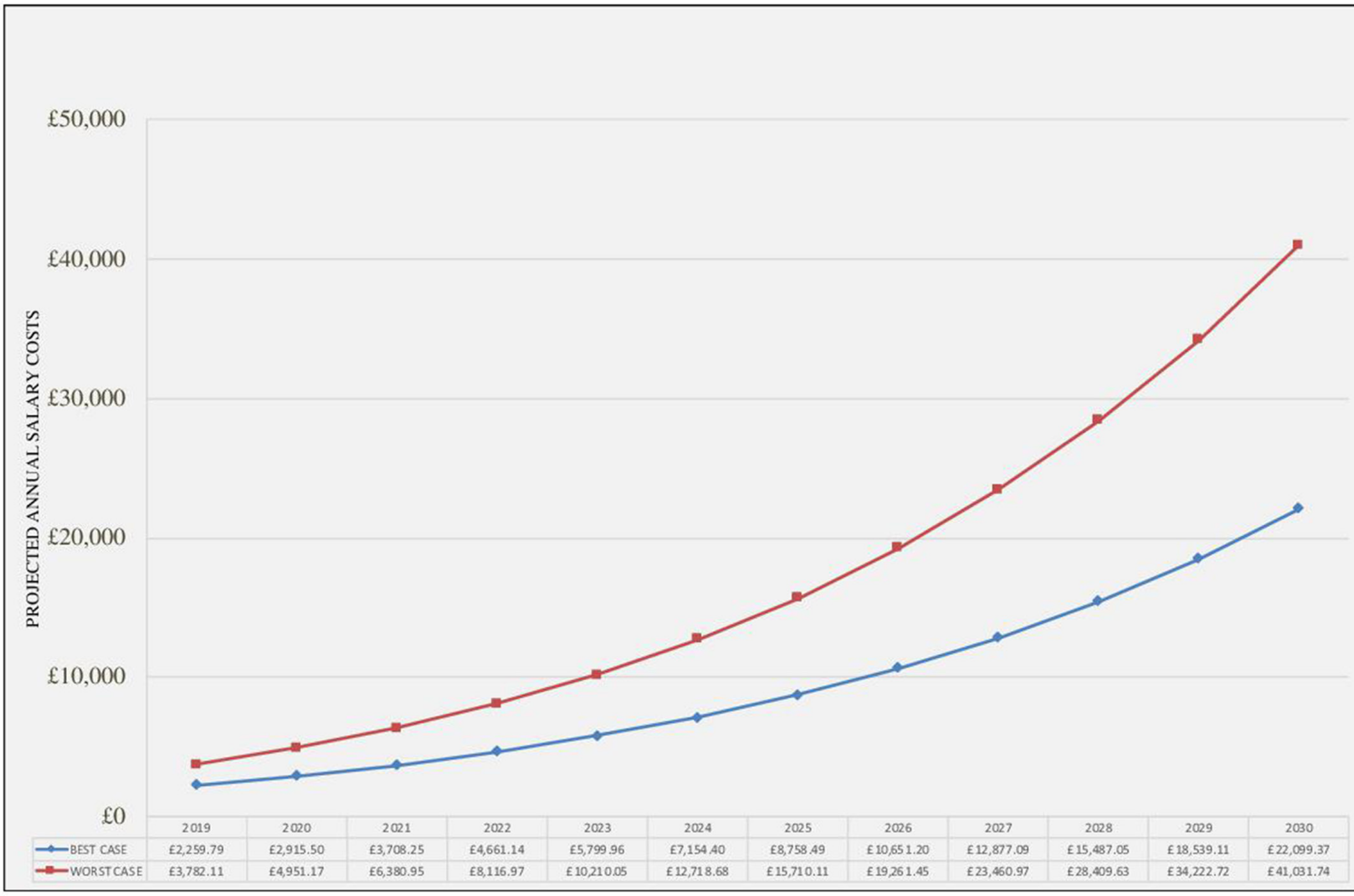
Sensitivity analysis

The aggregate salary costs to meet the required HRH annually within 95% CIs are presented in figure 3, in the form of the best and worst scenarios. In the best-case scenario, the salary cost to meet all the required HRH in 2020 is predicted to reach about £2.9 billion and is increasing up to £22.1 billion in 2030. While in the worst-case scenario, the cost is estimated to reach almost £5 billion in 2020 and is rising to approximately £41 billion in 2030. The SA demonstrates that the model results are relatively robust in relation to the narrow predictive intervals within the forecast.

DISCUSSION

Development of healthcare facilities

The model shows that attaining SDGs by 2030, particularly UHC for cancer care, requires an increase in the number and capacity of healthcare facilities. However, this model



	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BEST CASE	£2,259.79	£2,915.50	£3,708.25	£4,661.14	£5,799.96	£7,154.40	£8,758.49	£10,651.20	£12,877.09	£15,487.05	£18,539.11	£22,099.37
WORST CASE	£3,782.11	£4,951.17	£6,380.95	£8,116.97	£10,210.05	£12,718.68	£15,710.11	£19,261.45	£23,460.97	£28,409.63	£34,222.72	£41,031.74

Figure 3 Projected aggregate salary cost range, 2019–2030 (best and worst case scenarios).

predicts a decrease in the number of outpatient *puskesmas* over time as they are assumed to be upgraded into inpatient *puskesmas*. With one-third of all cancer being preventable and another third treatable if detected early,[4] primary healthcare centres (PHCs) are expected to play an important role not only in raising cancer awareness, but also in cancer screening and early detection. The predicted expansion in the number and capacity of inpatient *puskesmas* over 11-year period will improve patient access to care as the PHC acts as the cornerstone and the first contact of access to the public health system in Indonesia.

While PHCs are the main pillars in the early detection of cancer, secondary and tertiary hospitals are the main providers of cancer diagnostic and curative care. This model shows that although provision at these levels is set to increase in general, there are likely to be differences in hospital development between regions. The distribution of healthcare facilities is concentrated in the Java regions. The model predicts the increasing of type B, C and D hospitals across all regions, except for Maluku and Papua regions given the model assumptions. Given the previous 5-year trend of service development in Indonesia, the provision of type B hospitals in the easternmost region of Indonesia, the Papua region, is expected to remain at the status quo until 2030, with only two hospitals to cover its residents. Of the estimated 42.6% increase of type A hospital nationally from 2019 to 2030, no type A hospital is predicted to be available in the Maluku and Papua regions until 2030. Although the government has stated that there is an aim to provide at least one type A hospital in each of the Maluku and Papua regions,[27] this aim has not yet been implemented or developed any further. This implies that the equitable UHC for cancer care may not be fulfilled by 2030 unless concrete action is taken to address severe regional disparities. This paper, therefore, highlights a major challenge for Indonesia in terms of enabling equal access across the regions while suggesting the general needs for infrastructure expansion.

HRH requirements and gaps

Based on this model, the availability of GPs and nurses to meet the minimal requirement standard for health facilities set by MoH guideline is considered sufficient, even more than required in 2019, with SAR 1.35 and 1.11, respectively. It was also recently reported that the domestic supply of nurses is higher than the absorption capacity of the national healthcare market. During 2014–2019, approximately 2445 Indonesian nurses were sent to work abroad in Japan.[17]

A minimum SAR of 70% is considered an important milestone for achieving and sustaining health service provision.[21] However, of the 20 types of staff considered in this model, only four had an SAR of more than 70%

in 2019, which are internist, medical physicist, GP and nurse. The SARs among other basic medical specialists in 2019 were observed to be below 70%. The SARs among medical support specialists were found to be even lower than 50%, except for anaesthesiologists, which had around a 45% shortage. The current forecast has also indicated a shortage in para-clinical staff such as medical physicists (38% shortage) and RTTs (46% shortage). A more serious shortage was observed among oncologists. This shortage ranged from 54% for surgical oncologists to 97% for pulmonary oncologists. These shortages, particularly among oncologists, can be explained by various factors. First, the lack of subspecialist training programmes in Indonesia has become one of the barriers in meeting the need for a greater number of oncologists.[11] Second, the considerable length of time needed to complete the training, ranging from 6 to 8 years, causes a lack of interest among doctors to pursue a career in the oncology field.[11] Third, economic factors are important considerations as instead of receiving incentives, candidates have to pay for tuition fees for university-based training. This is in contrast to developed countries where doctors who undergo education through hospital-based services still receive incentives in the form of salaries. Therefore, it appears that the required increase in the number of oncologists is difficult to address over the short term.

This paper also shows that the geographical distribution of staff varies greatly. HRH prefer not to work in less developed services.[17] Compared with other regions, Java region has the largest of workforce of all types and most of the oncologists are concentrated here. On the contrary, there is no oncologist observed in the Maluku region, while the Papua region only has one surgical oncologist and one gynaecological oncologist. Hence, if the previous 5-year trends continue, this study predicts that the persistence of inadequate facilities and HRH provision may remain as the key drawbacks in attaining SDG targets and achieving UHC in cancer care.

Salary costs

The cost to meet the required 20 types of staff included in this model is estimated at just under £4 billion in 2020 and it is predicted to increase up to £31.5 billion in 11 years, in line with the additional number of staff needed. Of this, approximately £1.2 billion additional expenditure is needed to eliminate the current staffing gaps by 2020. This represents a 47.6% increase from the estimated 2019 salary cost (online supplemental appendix 11). This massive expansion in expenditure may not be viable in the short-term as the BPJS is currently suffering a huge financial deficit, which has existed since its first implementation in 2014.[28] Therefore, even if the required expanded workforce was available in the labour market, the budget space may be too limited to address all the new vacancies in the short-to-medium term.

Policy implications

This analysis demonstrates that an increase in investment is needed for medium-to-long term in the health sector, if SDG and UHC aims are to be met. Investments are required to increase HRH availability and must precede a considerable increase in health service coverage. Although it is estimated that there will be 42.6% increase in the number of type A hospitals between 2019 to 2030 nationally, this study also predicts that none of this increase will occur in the Easternmost regions by 2030 given the previous trends in Indonesia. Therefore, a significant part of this investment should focus on establishing more healthcare facilities in eastern Indonesia and expanding the capacity of existing facilities to cope with the increasing demand that will accompany population growth. A minimum of one type A hospital needs to be built in the Maluku and Papua regions to make sure that no regions are left behind in the move towards the UHC for cancer care.

Furthermore, the establishment of timely and accurate population-based cancer registries is needed to allow appropriate population-level policy decisions to address cancer. This data is crucial for determining the true cancer burden and it is currently not available in all regions in Indonesia.

Strengths and limitations

To date, this study is the first to empirically forecast specialist workforce requirements using a Markov model with a health service development analysis as the conceptual approach. Using this model, this study produces the first forecast of the healthcare facilities and oncologists needed annually in Indonesia over an 11-year horizon. This study highlights the way that a decision-analytical modelling approach can be used to inform workforce planning as a component of achieving UHC.

Inevitably, this model is also associated with limitations. First, this forecast focused solely on oncology services in the public sector for HRH of the 10 most common cancers in Indonesia. The private sector and other staff categories outside this sector were not considered due to data constraints. Thus, one should be aware when using or interpreting this forecast, that it does not necessarily represent the whole picture for either oncology services or the Indonesian health system. Second, this study only focused on forecasting the demand-side, not the supply-side. Consequently, the gaps do not represent the labour market equilibrium of supply-demand gaps but compares the staff currently employed against the staff needed. Third, the source of salary costs used in this model was taken from only one referral hospital in Indonesia (the largest), as most of the oncologists are concentrated in this hospital and discounting was not applied in the model. Also, the shortage calculation is only based on the need to meet the HRH minimum standard requirements for each facility level, which are still not well-defined, particularly for the oncologist group, regardless of local conditions. Thus, these uncertainties should always be taken into consideration when using the forecast as a decision-making aid. Lastly, the model did not account for the wider disease burden associated with the cancers considered.

Comparison of study findings to the existing literature

This study contributes to the literature in two main areas. First, the study provides valuable insights into the future requirements to meet important aims related to UHC and important SDGs (particularly SDG 3 target 4) in Indonesia. Several studies exist to analyse the current situation and the requirements of HRH in general in Indonesia.[11 17] However, the forecasting of the number of oncologists needed on annual basis has not yet been explored. Second, there are methodological contributions in terms of the use of decision-analytical approaches to inform HRH planning. In this study, decision-analytical modelling (a Markov model as part of a health service development approach) was used to inform HRH planning. This method has been applied in Ghana and has demonstrated the capability of projecting general HRH requirements.[21] This study adapted and developed this method in a specific sector (the oncology field) in Indonesia. While the application of this method in this area is still underutilised, this study demonstrates the potential scope of such modelling approaches.

Most countries, including Indonesia, offer no official guidelines for calculating the number of oncologists needed. One international guideline by the National Cancer Institute (NCI) estimated the number of oncologists needed in LMICs based on the estimated number of cancer patients.[29] However, this guideline estimated a nearly twofold higher oncologist requirement in 2019 for Indonesia than is estimated by the current model. For instance, an estimated of minimum 557 surgical oncologists are needed in 2019 according to the current model, compared with 994 using the NCI guideline. This guideline target is unlikely to be feasible and realistic in the short term given the long training period and limited subspecialty training places in Indonesia. Moreover, the slow economic growth in Indonesia, estimated at 5% gross domestic product growth,[30] is unlikely to permit the massive increase in workforce needs as calculated by this guideline. The requirements estimated by the current study are more plausible than those of these existing guidelines, given the current level of economic growth in Indonesia.

Conclusion

Scaling up oncology services in Indonesia to attain the targets set out in the SDGs, especially SDG 3 target 4 will require expansion and/or increase in the number and capability of healthcare facilities, especially in eastern Indonesia. If the trend of service development from the previous 5 years continues, equitable UHC for cancer care may not be fulfilled, as the Maluku and Papua regions are predicted to have no tertiary hospital even until 2030. This study predicts that the persistence of inadequate and inequitable access to facilities and HRH provision may remain a major barrier to attaining the SDG targets and achieving UHC in cancer care. Indonesia has a median of 39% of its HRH-related oncology requirements. Substantial staff shortages have been observed among healthcare professionals based on model requirements and these shortages are even more severe among oncologists. Addressing this issue requires at least a 47.6% increase in HRH expenditure, which may be difficult to meet due to budget constraints. Therefore, the government needs to prioritise investments to improve the quality and quantity of certain staff groups in more disadvantaged regions, particularly in Maluku and Papua.

This study demonstrates the application of decision-analytical modelling approach to planning HRH and facilities in a LMIC context. Such methods allow a in depth understanding of the resources needed to achieve UHC and allow a focus on particular gaps and challenges. Such methods could be utilised more widely in different disease areas and contexts to facilitate a detailed analysis of the HRH and facility requirements needed to achieve health-related SDGs.

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Patient consent for publication Not applicable.

Ethics approval This study did not require ethical approval as it involved modelling using published information.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. All data relevant to the study are included in the article or uploaded as online supplemental information. All of the data used to populate the model is available in the main paper or appendices. Where possible, the model itself will be made available for academic/health system planner use, in line with University guidelines.

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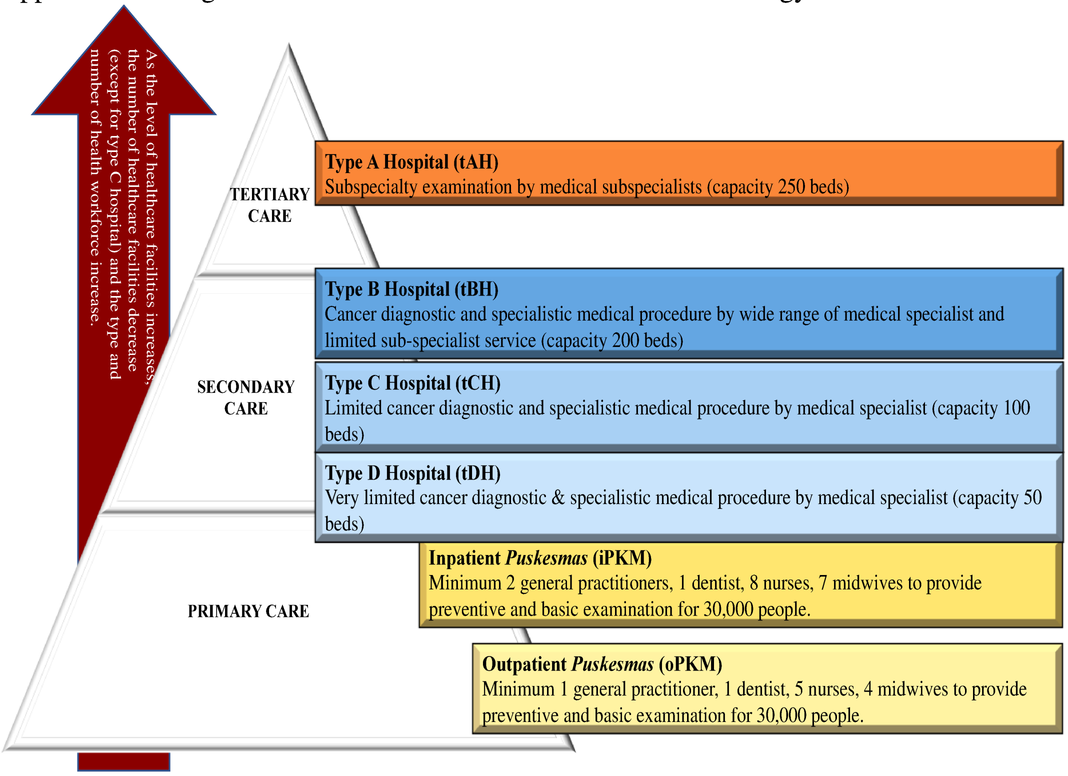
Appendix 1. Categorisation of Healthcare Facilities Related Oncology in Indonesia



Source: Adapted from NCCC (2015)

Appendix 2. Staffing Standard in Indonesia

STAFF	oPKM	iPKM	tDH	tCH	tBH	tAH	Source
General Practitioner	1	2	4	6	10	12	MoH, 2019
Nurse	5	8	33	67	200	250	MoH, 2019
Paediatrician	0	0	1	2	4	4	MoH, 2019
Obstetrician and Gynaecologist	0	0	1	2	4	4	MoH, 2019
Internist	0	0	1	2	4	4	MoH, 2019
General Surgeon	0	0	1	2	4	4	MoH, 2019
Pulmonologist	0	0	0	1	2	3	MoH, 2019
Radiologist	0	0	1	1	2	3	MoH, 2019
Clinical Pathologist	0	0	1	1	2	3	MoH, 2019
Anatomical Pathologist	0	0	1	1	1	2	MoH, 2019
Surgical Oncologist	0	0	0	0	1	2	NCCC, 2015
Medical Oncologist	0	0	0	0	1	1	NCCC, 2015
Paediatric Medical Oncologist	0	0	0	0	1	1	NCCC, 2015
Gynecologic Oncologist	0	0	0	0	1	2	NCCC, 2015
ENT Oncologist	0	0	0	0	1	1	NCCC, 2015
Urologic Oncologist	0	0	0	0	1	1	NCCC, 2015
Pulmonary Oncologist	0	0	0	0	1	1	NCCC, 2015
Radiation Oncologist	0	0	0	0	1	1	NCCC, 2015
Medical Physicist	0	0	0	0	1	1	NCCC, 2015
Radiation Therapy Technologist	0	0	0	0	1	1	NCCC, 2015

Appendix 3. Estimates of the required HRH were then the results of the calculated staffing levels and the total number of each type of healthcare facilities in a certain year as projected using the predictive model, using the following formula:

$$HRHr_{xy} = \sum[(oPKM_{xy} * SSr_{oPKM}) + (iPKM_{xy} * SSr_{iPKM}) + (tDH_{xy} * SSr_{tDH}) + (tCH_{xy} * SSr_{tCH}) + (tBH_{xy} * SSr_{tBH}) + (tAH_{xy} * SSr_{tAH})]$$

Where:

$\mathbf{HRHr_{xy}}$ represents the total HRH requirements for a particular type of staff ***r*,** in particular region ***x***, in year ***y*.**

$\mathbf{oPKM_{xy}}$ represents total number of oPKM in region ***x*** in year ***y***.

$\mathbf{SSr_{oPKM}}$ represents the staffing standard for staff type ***r*** at oPKM level.

Similar notations were applied to other type of healthcare facilities.

Appendix 4. Forecast of Healthcare Facilities and HRH-related Oncology in the Sumatera Region

REGION 1 - SUMATERA ISLAND												
Projected Population	**58,560,200**	**59,337,100**	**60,093,700**	**60,828,500**	**61,541,100**	**62,231,100**	**62,898,600**	**63,545,500**	**64,173,300**	**64,781,300**	**65,369,500**	**65,938,300**
HEALTH FACILITY/YEAR	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Outpatient Puskesmas	997	916	845	783	728	680	637	600	567	538	513	491
Inpatient Puskesmas	1651	1948	2226	2487	2732	2963	3181	3388	3583	3768	3945	4112
Type D Hospital	210	268	318	362	401	436	468	497	524	549	572	594
Type C Hospital	419	524	644	779	925	1082	1248	1422	1603	1791	1985	2184
Type B Hospital	82	88	94	101	110	119	129	140	153	167	182	198
Type A Hospital	10	11	13	14	15	17	18	20	22	24	26	29
Total Health Facilities	**3370**	**3755**	**4141**	**4526**	**4911**	**5296**	**5682**	**6067**	**6452**	**6837**	**7223**	**7608**
Overall Health facilities per 100,000 population	**5.755**	**6.329**	**6.890**	**7.440**	**7.980**	**8.511**	**9.033**	**9.547**	**10.054**	**10.554**	**11.049**	**11.538**
Primary care (Puskesmas) per 30,000 populati	**1.357**	**1.448**	**1.533**	**1.613**	**1.687**	**1.756**	**1.821**	**1.883**	**1.940**	**1.994**	**2.046**	**2.094**
Secondary care per 100,000 population	**1.215**	**1.482**	**1.758**	**2.042**	**2.333**	**2.630**	**2.933**	**3.240**	**3.553**	**3.869**	**4.190**	**4.514**
Type D hospital per 100,000 population	0.359	0.452	0.530	0.595	0.652	0.701	0.744	0.782	0.816	0.847	0.875	0.901
Type C Hospital per 100,000 population	0.716	0.882	1.072	1.280	1.503	1.738	1.984	2.237	2.498	2.765	3.037	3.313
Type B hospital per 100,000 population	0.141	0.148	0.157	0.167	0.178	0.191	0.205	0.221	0.238	0.257	0.278	0.300
Tertiary care per 100,0000 population	**0.018**	**0.019**	**0.021**	**0.023**	**0.025**	**0.027**	**0.029**	**0.031**	**0.034**	**0.037**	**0.040**	**0.043**

REGION 1 - SUMATERA ISLAND												
STAFF TYPE	**Year 2019**	**Year 2020**	**Year 2021**	**Year 2022**	**Year 2023**	**Year 2024**	**Year 2025**	**Year 2026**	**Year 2027**	**Year 2028**	**Year 2029**	**Year 2030**
General Practitioner	8602	10042	11528	13057	14624	16228	17866	19537	21238	22970	24730	26518
Nurse	72254	84522	97685	111669	126415	141878	158020	174811	192226	210244	228847	248020
Paediatrician	1419	1712	2034	2380	2750	3141	3552	3982	4429	4893	5373	5868
Obstetrician and Gynaecologist	1419	1712	2034	2380	2750	3141	3552	3982	4429	4893	5373	5868
Internist	1419	1712	2034	2380	2750	3141	3552	3982	4429	4893	5373	5868
General Surgeon	1419	1712	2034	2380	2750	3141	3552	3982	4429	4893	5373	5868
Anesthesiologist	928	1112	1308	1514	1731	1957	2194	2439	2695	2959	3232	3515
Radiologist	825	1002	1189	1385	1591	1805	2028	2259	2498	2745	2999	3260
Clinical Pathologist	825	1002	1189	1385	1591	1805	2028	2259	2498	2745	2999	3260
Anatomical Pathologist	732	902	1082	1270	1466	1670	1881	2099	2324	2554	2791	3033
Surgical Oncologist	103	111	119	129	140	152	165	180	196	214	234	255
Medical Oncologist	93	99	107	115	125	135	147	160	175	190	208	226
Paediatric Medical Oncologist	93	99	107	115	125	135	147	160	175	190	208	226
Gynecologic Oncologist	103	111	119	129	140	152	165	180	196	214	234	255
ENT Oncologist	93	99	107	115	125	135	147	160	175	190	208	226
Urologic Oncologist	93	99	107	115	125	135	147	160	175	190	208	226
Pulmonologic Oncologist	93	99	107	115	125	135	147	160	175	190	208	226
Radiation Oncologist	93	99	107	115	125	135	147	160	175	190	208	226
Medical Physicist	93	99	107	115	125	135	147	160	175	190	208	226
Radiation Therapy Technologist	93	99	107	115	125	135	147	160	175	190	208	226
TOTAL	**90788**	**106448**	**123209**	**140982**	**159696**	**179294**	**199732**	**220973**	**242984**	**265741**	**289220**	**313401**

Appendix 5. Forecast of Healthcare Facilities and HRH-related Oncology in the Java Region

REGION 2 - JAVA ISLAND

Projected Population	**151,061,800**	**152,449,900**	**153,797,800**	**155,101,700**	**156,361,000**	**157,573,300**	**158,738,000**	**159,852,700**	**160,912,700**	**161,917,500**	**162,864,900**	**163,754,800**
HEALTH FACILITY/YEAR	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Outpatient Puskesmas	1371	1222	1090	973	869	776	694	621	556	498	447	402
Inpatient Puskesmas	2226	2604	2950	3265	3555	3820	4063	4287	4493	4683	4858	5020
Type D Hospital	408	531	639	736	822	900	969	1032	1089	1141	1188	1231
Type C Hospital	718	892	1090	1310	1545	1795	2055	2325	2601	2882	3167	3454
Type B Hospital	271	313	362	418	481	551	630	717	812	917	1031	1154
Type A Hospital	41	44	45	45	45	46	46	47	47	48	48	49
Total Health Facilities	**5035**	**5606**	**6176**	**6747**	**7317**	**7888**	**8458**	**9029**	**9599**	**10170**	**10740**	**11311**
Overall Health facilities per 100,000 population	**3.333**	**3.677**	**4.016**	**4.350**	**4.680**	**5.006**	**5.328**	**5.648**	**5.965**	**6.281**	**6.594**	**6.907**
Primary care (Puskesmas) per 30,000 populati	**0.714**	**0.753**	**0.788**	**0.820**	**0.849**	**0.875**	**0.899**	**0.921**	**0.941**	**0.960**	**0.977**	**0.993**
Secondary care per 100,000 population	**0.925**	**1.138**	**1.360**	**1.588**	**1.822**	**2.060**	**2.302**	**2.549**	**2.798**	**3.051**	**3.307**	**3.566**
Type D hospital per 100,000 population	0.270	0.348	0.416	0.475	0.526	0.571	0.611	0.646	0.677	0.705	0.730	0.752
Type C Hospital per 100,000 population	0.475	0.585	0.709	0.844	0.988	1.139	1.295	1.454	1.616	1.780	1.944	2.109
Type B hospital per 100,000 population	0.180	0.205	0.235	0.269	0.307	0.350	0.397	0.448	0.505	0.567	0.633	0.705
Tertiary care per 100,0000 population	**0.027**	**0.029**	**0.029**	**0.029**	**0.029**	**0.029**	**0.029**	**0.029**	**0.029**	**0.029**	**0.030**	**0.030**

REGION 2 - JAVA ISLAND

STAFF TYPE	**Year 2019**	**Year 2020**	**Year 2021**	**Year 2022**	**Year 2023**	**Year 2024**	**Year 2025**	**Year 2026**	**Year 2027**	**Year 2028**	**Year 2029**	**Year 2030**
General Practitioner	14969	17558	20242	23021	25890	28845	31883	35001	38196	41466	44807	48219
Nurse	150798	177743	206714	237783	270909	306055	343182	382253	423231	466080	510763	557243
Paediatrician	3094	3741	4446	5205	6017	6877	7784	8736	9730	10765	11839	12951
Obstetrician and Gynaecologist	3094	3741	4446	5205	6017	6877	7784	8736	9730	10765	11839	12951
Internist	3094	3741	4446	5205	6017	6877	7784	8736	9730	10765	11839	12951
General Surgeon	3094	3741	4446	5205	6017	6877	7784	8736	9730	10765	11839	12951
Anesthesiologist	2146	2581	3038	3523	4036	4577	5145	5741	6364	7013	7689	8391
Radiologist	1792	2180	2587	3016	3465	3934	4423	4931	5457	6001	6562	7140
Clinical Pathologist	1792	2180	2587	3016	3465	3934	4423	4931	5457	6001	6562	7140
Anatomical Pathologist	1479	1823	2181	2553	2939	3337	3747	4167	4597	5036	5483	5937
Surgical Oncologist	354	401	451	508	571	643	722	810	907	1013	1127	1252
Medical Oncologist	313	357	406	463	526	597	676	763	860	965	1079	1203
Paediatric Medical Oncologist	313	357	406	463	526	597	676	763	860	965	1079	1203
Gynecologic Oncologist	354	401	451	508	571	643	722	810	907	1013	1127	1252
ENT Oncologist	313	357	406	463	526	597	676	763	860	965	1079	1203
Urologic Oncologist	313	357	406	463	526	597	676	763	860	965	1079	1203
Pulmonologic Oncologist	313	357	406	463	526	597	676	763	860	965	1079	1203
Radiation Oncologist	313	357	406	463	526	597	676	763	860	965	1079	1203
Medical Physicist	313	357	406	463	526	597	676	763	860	965	1079	1203
Radiation Therapy Technologist	313	357	406	463	526	597	676	763	860	965	1079	1203
TOTAL	**188560**	**222682**	**259286**	**298449**	**340120**	**384251**	**430791**	**479694**	**530913**	**584401**	**640112**	**698000**

Appendix 6. Forecast of Healthcare Facilities and HRH-related Oncology in the Bali and the Nusa Tenggara Region

REGION 3 - BALI AND THE NUSA TENGGARA ISLANDS

Projected Population	**14,863,500**	**15,047,800**	**15,229,900**	**15,409,700**	**15,586,600**	**15,760,900**	**15,932,400**	**16,101,200**	**16,267,600**	**16,431,700**	**16,592,900**	**16,751,400**
HEALTH FACILITY/YEAR	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Outpatient Puskesmas	327	319	312	305	298	292	286	280	275	270	265	261
Inpatient Puskesmas	364	402	439	475	511	545	579	611	643	675	705	735
Type D Hospital	51	58	63	68	72	76	79	82	84	87	89	91
Type C Hospital	87	108	131	154	178	203	228	253	278	303	328	353
Type B Hospital	16	20	23	28	33	39	45	51	59	67	75	84
Type A Hospital	3	3	3	3	3	3	3	3	3	3	3	3
Total Health Facilities	**848**	**910**	**972**	**1033**	**1095**	**1157**	**1219**	**1280**	**1342**	**1404**	**1466**	**1527**
Overall Health facilities per 100,000 population	**5.705**	**6.046**	**6.379**	**6.705**	**7.025**	**7.339**	**7.648**	**7.951**	**8.250**	**8.543**	**8.832**	**9.117**
Primary care (Puskesmas) per 30,000 populati	**1.395**	**1.438**	**1.479**	**1.518**	**1.556**	**1.592**	**1.627**	**1.661**	**1.693**	**1.724**	**1.754**	**1.783**
Secondary care per 100,000 population	**1.036**	**1.233**	**1.430**	**1.625**	**1.819**	**2.012**	**2.205**	**2.396**	**2.587**	**2.778**	**2.967**	**3.156**
Type D hospital per 100,000 population	0.346	0.385	0.416	0.441	0.462	0.479	0.494	0.507	0.518	0.528	0.537	0.545
Type C Hospital per 100,000 population	0.582	0.719	0.859	1.002	1.145	1.288	1.430	1.570	1.708	1.844	1.978	2.110
Type B hospital per 100,000 population	0.108	0.130	0.154	0.182	0.212	0.245	0.281	0.320	0.361	0.406	0.452	0.502
Tertiary care per 100,0000 population	**0.020**	**0.020**	**0.020**	**0.019**	**0.019**	**0.019**	**0.019**	**0.019**	**0.018**	**0.018**	**0.018**	**0.018**

REGION 3 - BALI AND THE NUSA TENGGARA ISLANDS

STAFF TYPE	**Year 2019**	**Year 2020**	**Year 2021**	**Year 2022**	**Year 2023**	**Year 2024**	**Year 2025**	**Year 2026**	**Year 2027**	**Year 2028**	**Year 2029**	**Year 2030**
General Practitioner	1976	2235	2500	2769	3044	3324	3608	3897	4189	4486	4787	5093
Nurse	15999	18624	21380	24261	27264	30384	33618	36965	40422	43988	47660	51438
Paediatrician	301	364	431	501	573	648	725	805	887	971	1058	1146
Obstetrician and Gynaecologist	301	364	431	501	573	648	725	805	887	971	1058	1146
Internist	301	364	431	501	573	648	725	805	887	971	1058	1146
General Surgeon	301	364	431	501	573	648	725	805	887	971	1058	1146
Anesthesiologist	201	240	280	321	365	409	456	504	553	605	657	712
Radiologist	179	214	250	287	326	365	405	446	489	532	576	622
Clinical Pathologist	179	214	250	287	326	365	405	446	489	532	576	622
Anatomical Pathologist	160	192	224	256	290	323	357	392	427	462	498	535
Surgical Oncologist	22	26	29	34	39	45	51	57	65	73	81	90
Medical Oncologist	19	23	26	31	36	42	48	54	62	70	78	87
Paediatric Medical Oncologist	19	23	26	31	36	42	48	54	62	70	78	87
Gynecologic Oncologist	22	26	29	34	39	45	51	57	65	73	81	90
ENT Oncologist	19	23	26	31	36	42	48	54	62	70	78	87
Urologic Oncologist	19	23	26	31	36	42	48	54	62	70	78	87
Pulmonologic Oncologist	19	23	26	31	36	42	48	54	62	70	78	87
Radiation Oncologist	19	23	26	31	36	42	48	54	62	70	78	87
Medical Physicist	19	23	26	31	36	42	48	54	62	70	78	87
Radiation Therapy Technologist	19	23	26	31	36	42	48	54	62	70	78	87
TOTAL	**20093**	**23407**	**26879**	**30502**	**34272**	**38183**	**42234**	**46421**	**50741**	**55193**	**59774**	**64483**

Appendix 7. Forecast of Healthcare Facilities and HRH-related Oncology in the Kalimantan Region

REGION 4 - KALIMANTAN ISLAND												
Projected Population	**16,491,700**	**16,769,700**	**17,042,800**	**17,311,000**	**17,573,800**	**17,831,100**	**18,082,600**	**18,328,700**	**18,570,200**	**18,806,500**	**19,037,900**	**19,264,000**
HEALTH FACILITY/YEAR	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Outpatient Puskesmas	392	367	345	324	305	288	272	258	245	233	223	213
Inpatient Puskesmas	533	612	688	760	830	896	960	1021	1080	1136	1191	1243
Type D Hospital	53	64	72	80	86	92	97	101	106	109	113	117
Type C Hospital	110	138	169	203	238	275	314	353	394	435	477	520
Type B Hospital	22	25	27	31	34	38	43	48	53	59	66	73
Type A Hospital	3	3	3	3	3	3	3	4	4	4	4	4
Total Health Facilities	**1113**	**1209**	**1305**	**1401**	**1497**	**1593**	**1689**	**1785**	**1881**	**1977**	**2073**	**2169**
Overall Health facilities per 100,000 population	**6.749**	**7.209**	**7.657**	**8.093**	**8.518**	**8.934**	**9.340**	**9.739**	**10.129**	**10.512**	**10.889**	**11.259**
Primary care (Puskesmas) per 30,000 populatior	**1.683**	**1.752**	**1.818**	**1.879**	**1.937**	**1.992**	**2.044**	**2.093**	**2.140**	**2.185**	**2.227**	**2.268**
Secondary care per 100,000 population	**1.122**	**1.349**	**1.579**	**1.810**	**2.042**	**2.274**	**2.508**	**2.741**	**2.976**	**3.211**	**3.446**	**3.681**
Type D hospital per 100,000 population	0.319	0.379	0.425	0.461	0.490	0.515	0.535	0.553	0.568	0.582	0.594	0.606
Type C Hospital per 100,000 population	0.668	0.824	0.993	1.172	1.356	1.544	1.735	1.927	2.120	2.313	2.506	2.698
Type B hospital per 100,000 population	0.135	0.146	0.161	0.177	0.195	0.215	0.237	0.261	0.287	0.315	0.346	0.378
Tertiary care per 100,0000 population	**0.018**	**0.020**	**0.019**	**0.019**	**0.019**	**0.019**	**0.019**	**0.019**	**0.019**	**0.019**	**0.019**	**0.019**

REGION 4 - KALIMANTAN ISLAND												
STAFF TYPE	**Year 2019**	**Year 2020**	**Year 2021**	**Year 2022**	**Year 2023**	**Year 2024**	**Year 2025**	**Year 2026**	**Year 2027**	**Year 2028**	**Year 2029**	**Year 2030**
General Practitioner	2588	2960	3340	3728	4123	4524	4932	5346	5765	6190	6621	7056
Nurse	20540	23816	27271	30899	34687	38626	42709	46932	51290	55781	60403	65153
Paediatrician	374	451	534	622	714	810	910	1014	1121	1231	1345	1462
Obstetrician and Gynaecologist	374	451	534	622	714	810	910	1014	1121	1231	1345	1462
Internist	374	451	534	622	714	810	910	1014	1121	1231	1345	1462
General Surgeon	374	451	534	622	714	810	910	1014	1121	1231	1345	1462
Anesthesiologist	245	292	341	391	444	500	557	616	677	740	806	873
Radiologist	216	261	306	354	403	454	507	561	617	674	733	793
Clinical Pathologist	216	261	306	354	403	454	507	561	617	674	733	793
Anatomical Pathologist	191	233	276	320	366	412	460	510	560	611	663	717
Surgical Oncologist	28	31	34	37	41	45	50	55	61	67	73	80
Medical Oncologist	25	28	31	34	38	42	46	51	57	63	69	76
Paediatric Medical Oncologist	25	28	31	34	38	42	46	51	57	63	69	76
Gynecologic Oncologist	28	31	34	37	41	45	50	55	61	67	73	80
ENT Oncologist	25	28	31	34	38	42	46	51	57	63	69	76
Urologic Oncologist	25	28	31	34	38	42	46	51	57	63	69	76
Pulmonologic Oncologist	25	28	31	34	38	42	46	51	57	63	69	76
Radiation Oncologist	25	28	31	34	38	42	46	51	57	63	69	76
Medical Physicist	25	28	31	34	38	42	46	51	57	63	69	76
Radiation Therapy Technologist	25	28	31	34	38	42	46	51	57	63	69	76
TOTAL	**25750**	**29910**	**34289**	**38879**	**43665**	**48635**	**53782**	**59101**	**64585**	**70232**	**76040**	**82004**

Appendix 8. Forecast of Healthcare Facilities and HRH-related Oncology in the Sulawesi Region

REGION 5 - SULAWESI ISLAND												
Projected Population	**19,699,800**	**19,934,000**	**20,163,100**	**20,386,500**	**20,603,900**	**20,815,000**	**21,019,800**	**21,218,300**	**21,411,200**	**21,598,100**	**21,779,100**	**21,953,500**
HEALTH FACILITY/YEAR	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Outpatient Puskesmas	680	668	657	646	635	625	615	606	597	588	580	572
Inpatient Puskesmas	658	711	762	813	861	909	955	1000	1044	1086	1128	1168
Type D Hospital	75	87	96	102	107	111	115	118	121	123	126	128
Type C Hospital	144	188	235	285	337	390	444	499	554	609	665	721
Type B Hospital	36	39	43	47	52	57	63	70	77	85	94	104
Type A Hospital	3	3	3	3	3	3	4	4	4	4	4	4
Total Health Facilities	**1593**	**1693**	**1793**	**1893**	**1993**	**2093**	**2192**	**2292**	**2392**	**2492**	**2592**	**2692**
Overall Health facilities per 100,000 population	**8.086**	**8.491**	**8.890**	**9.283**	**9.671**	**10.053**	**10.431**	**10.804**	**11.174**	**11.540**	**11.903**	**12.264**
Primary care (Puskesmas) per 30,000 populati	**2.038**	**2.075**	**2.112**	**2.146**	**2.179**	**2.211**	**2.241**	**2.270**	**2.299**	**2.326**	**2.352**	**2.378**
Secondary care per 100,000 population	**1.294**	**1.573**	**1.852**	**2.130**	**2.408**	**2.684**	**2.961**	**3.236**	**3.512**	**3.787**	**4.063**	**4.338**
Type D hospital per 100,000 population	0.378	0.436	0.474	0.501	0.521	0.535	0.547	0.556	0.564	0.571	0.578	0.584
Type C Hospital per 100,000 population	0.733	0.942	1.166	1.399	1.636	1.874	2.113	2.350	2.586	2.820	3.053	3.283
Type B hospital per 100,000 population	0.183	0.195	0.211	0.230	0.251	0.275	0.301	0.330	0.362	0.396	0.432	0.471
Tertiary care per 100,0000 population	**0.016**	**0.017**	**0.017**	**0.017**	**0.017**	**0.017**	**0.017**	**0.017**	**0.017**	**0.017**	**0.017**	**0.017**

REGION 5 - SULAWESI ISLAND												
STAFF TYPE	**Year 2019**	**Year 2020**	**Year 2021**	**Year 2022**	**Year 2023**	**Year 2024**	**Year 2025**	**Year 2026**	**Year 2027**	**Year 2028**	**Year 2029**	**Year 2030**
General Practitioner	3558	3994	4442	4901	5368	5843	6324	6813	7307	7807	8313	8824
Nurse	28772	33108	37675	42448	47403	52524	57800	63226	68795	74505	80353	86338
Paediatrician	520	632	750	874	1002	1134	1270	1410	1552	1698	1847	1998
Obstetrician and Gynaecologist	520	632	750	874	1002	1134	1270	1410	1552	1698	1847	1998
Internist	520	632	750	874	1002	1134	1270	1410	1552	1698	1847	1998
General Surgeon	520	632	750	874	1002	1134	1270	1410	1552	1698	1847	1998
Anesthesiologist	342	408	476	545	617	691	766	844	925	1007	1091	1178
Radiologist	300	363	426	491	558	626	696	767	840	914	990	1067
Clinical Pathologist	300	363	426	491	558	626	696	767	840	914	990	1067
Anatomical Pathologist	261	320	380	441	503	566	629	694	759	825	892	960
Surgical Oncologist	42	46	49	54	59	64	70	77	85	93	101	111
Medical Oncologist	39	42	46	50	55	61	67	74	81	89	98	107
Paediatric Medical Oncologist	39	42	46	50	55	61	67	74	81	89	98	107
Gynecologic Oncologist	42	46	49	54	59	64	70	77	85	93	101	111
ENT Oncologist	39	42	46	50	55	61	67	74	81	89	98	107
Urologic Oncologist	39	42	46	50	55	61	67	74	81	89	98	107
Pulmonologic Oncologist	39	42	46	50	55	61	67	74	81	89	98	107
Radiation Oncologist	39	42	46	50	55	61	67	74	81	89	98	107
Medical Physicist	39	42	46	50	55	61	67	74	81	89	98	107
Radiation Therapy Technologist	39	42	46	50	55	61	67	74	81	89	98	107
TOTAL	**36009**	**41512**	**47294**	**53324**	**59575**	**66027**	**72670**	**79493**	**86492**	**93662**	**101000**	**108505**

Appendix 9. Forecast of Healthcare Facilities and HRH-related Oncology in the Maluku Region

REGION 6 - MALUKU ISLAND												
Projected Population	**3,058,700**	**3,110,700**	**3,162,300**	**3,213,500**	**3,264,200**	**3,314,200**	**3,363,700**	**3,412,600**	**3,461,100**	**3,509,200**	**3,556,600**	**3,603,600**
HEALTH FACILITY/YEAR	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Outpatient Puskesmas	122	111	102	94	87	82	77	73	69	66	64	62
Inpatient Puskesmas	234	284	330	373	414	453	489	524	557	588	618	646
Type D Hospital	33	43	54	66	79	93	107	122	138	154	170	187
Type C Hospital	13	15	18	21	24	28	32	37	43	48	55	61
Type B Hospital	5	6	7	7	8	9	10	11	12	14	15	17
Type A Hospital	0	0	0	0	0	0	0	0	0	0	0	0
Total Health Facilities	**407**	**459**	**510**	**562**	**613**	**665**	**716**	**768**	**819**	**871**	**922**	**974**
Overall Health facilities per 100,000 population	**13.306**	**14.739**	**16.128**	**17.473**	**18.779**	**20.050**	**21.286**	**22.490**	**23.663**	**24.806**	**25.924**	**27.015**
Primary care (Puskesmas) per 30,000 populati	**3.492**	**3.807**	**4.097**	**4.364**	**4.611**	**4.840**	**5.051**	**5.247**	**5.428**	**5.596**	**5.752**	**5.896**
Secondary care per 100,000 population	**1.667**	**2.050**	**2.471**	**2.926**	**3.409**	**3.918**	**4.450**	**5.001**	**5.570**	**6.154**	**6.751**	**7.361**
Type D hospital per 100,000 population	1.066	1.368	1.697	2.048	2.416	2.797	3.187	3.583	3.982	4.383	4.784	5.182
Type C Hospital per 100,000 population	0.427	0.492	0.566	0.650	0.744	0.849	0.965	1.091	1.229	1.377	1.535	1.703
Type B hospital per 100,000 population	0.173	0.190	0.208	0.227	0.249	0.272	0.298	0.327	0.359	0.394	0.432	0.475
Tertiary care per 100,0000 population	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**

REGION 6 - MALUKU ISLAND												
STAFF TYPE	**Year 2019**	**Year 2020**	**Year 2021**	**Year 2022**	**Year 2023**	**Year 2024**	**Year 2025**	**Year 2026**	**Year 2027**	**Year 2028**	**Year 2029**	**Year 2030**
General Practitioner	852	1000	1150	1303	1458	1617	1780	1945	2114	2286	2462	2641
Nurse	5495	6436	7434	8490	9606	10781	12018	13319	14683	16114	17611	19177
Paediatrician	80	97	116	137	160	185	212	241	273	306	341	378
Obstetrician and Gynaecologist	80	97	116	137	160	185	212	241	273	306	341	378
Internist	80	97	116	137	160	185	212	241	273	306	341	378
General Surgeon	80	97	116	137	160	185	212	241	273	306	341	378
Anesthesiologist	62	76	91	109	128	148	170	193	218	244	271	299
Radiologist	56	70	85	101	119	139	160	182	205	230	255	282
Clinical Pathologist	56	70	85	101	119	139	160	182	205	230	255	282
Anatomical Pathologist	51	64	78	94	111	130	150	171	193	216	240	265
Surgical Oncologist	5	6	7	7	8	9	10	11	12	14	15	17
Medical Oncologist	5	6	7	7	8	9	10	11	12	14	15	17
Paediatric Medical Oncologist	5	6	7	7	8	9	10	11	12	14	15	17
Gynecologic Oncologist	5	6	7	7	8	9	10	11	12	14	15	17
ENT Oncologist	5	6	7	7	8	9	10	11	12	14	15	17
Urologic Oncologist	5	6	7	7	8	9	10	11	12	14	15	17
Pulmonologic Oncologist	5	6	7	7	8	9	10	11	12	14	15	17
Radiation Oncologist	5	6	7	7	8	9	10	11	12	14	15	17
Medical Physicist	5	6	7	7	8	9	10	11	12	14	15	17
Radiation Therapy Technologist	5	6	7	7	8	9	10	11	12	14	15	17
TOTAL	**6946**	**8161**	**9452**	**10819**	**12263**	**13785**	**15386**	**17068**	**18832**	**20680**	**22612**	**24630**

Appendix 10. Forecast of Healthcare Facilities and HRH-related Oncology in the Papua Region

REGION 7 - PAPUA ISLAND												
Projected Population	**4,338,900**	**4,407,200**	**4,494,800**	**4,571,400**	**4,646,800**	**4,721,000**	**4,793,900**	**4,865,500**	**4,936,000**	**5,005,200**	**5,073,100**	**5,139,500**
HEALTH FACILITY/YEAR	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Outpatient Puskesmas	159	140	125	112	102	93	86	80	75	70	67	64
Inpatient Puskesmas	420	504	582	655	722	785	843	898	950	999	1045	1089
Type D Hospital	38	59	81	105	130	155	180	206	231	257	282	307
Type C Hospital	23	28	34	43	54	66	81	98	118	139	163	189
Type B Hospital	2	2	2	2	2	2	2	2	2	2	2	2
Type A Hospital	0	0	0	0	0	0	0	0	0	0	0	0
Total Health Facilities	**642**	**734**	**826**	**917**	**1009**	**1101**	**1193**	**1284**	**1376**	**1468**	**1560**	**1651**
Overall Health facilities per 100,000 population	**14.796**	**16.649**	**18.366**	**20.065**	**21.714**	**23.316**	**24.875**	**26.395**	**27.877**	**29.325**	**30.741**	**32.129**
Primary care (Puskesmas) per 30,000 populati	**4.003**	**4.390**	**4.722**	**5.033**	**5.317**	**5.576**	**5.812**	**6.029**	**6.227**	**6.410**	**6.577**	**6.731**
Secondary care per 100,000 population	**1.452**	**2.015**	**2.625**	**3.287**	**3.991**	**4.731**	**5.501**	**6.298**	**7.119**	**7.959**	**8.818**	**9.693**
Type D hospital per 100,000 population	0.870	1.334	1.810	2.299	2.790	3.277	3.758	4.228	4.685	5.128	5.555	5.966
Type C Hospital per 100,000 population	0.528	0.629	0.763	0.938	1.152	1.404	1.695	2.023	2.387	2.785	3.218	3.682
Type B hospital per 100,000 population	0.053	0.053	0.052	0.051	0.050	0.049	0.048	0.048	0.047	0.046	0.046	0.045
Tertiary care per 100,0000 population	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**

REGION 7 - PAPUA ISLAND												
STAFF TYPE	**Year 2019**	**Year 2020**	**Year 2021**	**Year 2022**	**Year 2023**	**Year 2024**	**Year 2025**	**Year 2026**	**Year 2027**	**Year 2028**	**Year 2029**	**Year 2030**
General Practitioner	1311	1574	1844	2122	2408	2702	3003	3313	3630	3955	4287	4627
Nurse	7400	8997	10732	12603	14610	16752	19025	21429	23961	26617	29396	32293
Paediatrician	93	123	159	200	246	297	352	412	476	545	618	694
Obstetrician and Gynaecologist	93	123	159	200	246	297	352	412	476	545	618	694
Internist	93	123	159	200	246	297	352	412	476	545	618	694
General Surgeon	93	123	159	200	246	297	352	412	476	545	618	694
Anesthesiologist	68	93	123	155	190	228	268	311	356	403	452	503
Radiologist	65	91	120	153	188	226	266	309	354	401	450	500
Clinical Pathologist	65	91	120	153	188	226	266	309	354	401	450	500
Anatomical Pathologist	63	89	118	150	185	223	264	306	351	398	447	498
Surgical Oncologist	2	2	2	2	2	2	2	2	2	2	2	2
Medical Oncologist	2	2	2	2	2	2	2	2	2	2	2	2
Paediatric Medical Oncologist	2	2	2	2	2	2	2	2	2	2	2	2
Gynecologic Oncologist	2	2	2	2	2	2	2	2	2	2	2	2
ENT Oncologist	2	2	2	2	2	2	2	2	2	2	2	2
Urologic Oncologist	2	2	2	2	2	2	2	2	2	2	2	2
Pulmonologic Oncologist	2	2	2	2	2	2	2	2	2	2	2	2
Radiation Oncologist	2	2	2	2	2	2	2	2	2	2	2	2
Medical Physicist	2	2	2	2	2	2	2	2	2	2	2	2
Radiation Therapy Technologist	2	2	2	2	2	2	2	2	2	2	2	2
TOTAL	**9366**	**11453**	**13717**	**16159**	**18776**	**21565**	**24524**	**27647**	**30933**	**34377**	**37975**	**41722**

Appendix 11. Annual Incremental Costs Estimation 2020 - 2030

STAFF TYPE	Current Expenditure (2019)	Expenditure for Projected HRH Requirement (2019)	Expenditure Gap (2019)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
General Practitioner	£549.03	£406.74	£142.30	£113.46	£134.65	£159.10	£187.19	£219.44	£256.43	£298.79	£347.27	£402.69	£465.96	£538.13
Nurse	£1,521.56	£1,369.48	£152.08	£396.91	£482.72	£583.48	£700.83	£837.31	£995.77	£1,179.45	£1,392.01	£1,637.60	£1,920.91	£2,247.26
Paediatrician	£65.95	£114.55	£48.60	£38.05	£47.06	£57.55	£69.72	£83.85	£100.23	£119.17	£141.06	£166.31	£195.38	£228.82
Obstetrician and gynaecologist	£148.95	£217.65	£68.69	£72.29	£89.42	£109.34	£132.47	£159.32	£190.43	£226.43	£268.01	£315.98	£371.22	£434.76
Internist	£82.35	£114.55	£32.20	£38.05	£47.06	£57.55	£69.72	£83.85	£100.23	£119.17	£141.06	£166.31	£195.38	£228.82
General Surgeon	£88.36	£217.65	£129.29	£72.29	£89.42	£109.34	£132.47	£159.32	£190.43	£226.43	£268.01	£315.98	£371.22	£434.76
Anesthesiologist	£91.10	£165.88	£74.78	£53.64	£64.91	£78.40	£94.18	£112.58	£134.00	£158.87	£187.69	£221.02	£259.51	£303.88
Radiologist	£47.21	£111.51	£64.29	£37.78	£45.73	£55.11	£66.01	£78.65	£93.29	£110.21	£129.72	£152.18	£178.01	£207.66
Clinical Pathologist	£30.77	£86.97	£56.20	£29.47	£35.67	£42.98	£51.49	£61.35	£72.77	£85.96	£101.18	£118.70	£138.85	£161.98
Anatomical Pathologist	£11.90	£74.41	£62.50	£26.52	£32.02	£38.46	£45.88	£54.44	£64.27	£75.56	£88.49	£103.30	£120.22	£139.55
Surgical Oncologist	£6.86	£18.81	£11.96	£4.29	£5.18	£6.39	£7.87	£9.67	£11.85	£14.47	£17.59	£21.31	£25.72	£30.93
Medical Oncologist	£1.04	£5.32	£4.28	£1.25	£1.54	£1.92	£2.37	£2.92	£3.60	£4.40	£5.37	£6.52	£7.88	£9.49
Paediatric Medical Oncologist	£1.19	£11.76	£10.58	£2.76	£3.42	£4.24	£5.24	£6.47	£7.95	£9.74	£11.87	£14.41	£17.43	£20.99
Gynecologic Oncologist	£3.85	£20.62	£16.77	£4.71	£5.68	£7.00	£8.63	£10.60	£12.99	£15.86	£19.29	£23.36	£28.20	£33.91
ENT Oncologist	£1.69	£18.69	£17.00	£4.38	£5.43	£6.73	£8.33	£10.28	£12.64	£15.47	£18.87	£22.90	£27.70	£33.36
Urologic Oncologist	£0.48	£18.37	£17.89	£4.31	£5.34	£6.62	£8.19	£10.10	£12.42	£15.21	£18.54	£22.51	£27.22	£32.78
Pulmonary Oncologist	£0.86	£14.18	£13.32	£3.32	£4.12	£5.11	£6.32	£7.80	£9.59	£11.74	£14.31	£17.38	£21.01	£25.31
Radiation Oncologist	£5.35	£27.07	£21.73	£6.35	£7.86	£9.75	£12.07	£14.89	£18.31	£22.41	£27.32	£33.17	£40.11	£48.31
Medical Physicist	£3.29	£3.71	£0.41	£0.87	£1.08	£1.33	£1.65	£2.04	£2.51	£3.07	£3.74	£4.54	£5.49	£6.61
Radiation Therapy Technologist	£1.86	£3.05	£1.19	£0.71	£0.88	£1.10	£1.36	£1.68	£2.06	£2.52	£3.07	£3.73	£4.51	£5.43
TOTAL	**£2,663.66**	**£3,020.95**	**£357.29**	**£911.41**	**£1,109.21**	**£1,341.47**	**£1,612.00**	**£1,926.58**	**£2,291.75**	**£2,714.93**	**£3,204.48**	**£3,769.90**	**£4,421.93**	**£5,172.72**